

Tachycardia in Trauma.....

How Not To Miss The Forest For The Trees

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Plan

- Discuss case with opportunities for improvement
- Discuss subsequent Performance Improvement process
- Discuss shock pathophysiology and end points of resuscitation
- Discuss second case with less opportunities for improvement

Case #1

Event: 27 year old male unrestrained driver of car involved in high speed head-on collision

Massive front end damage, mostly on driver's side – airbag deployed, broken steering wheel, windshield completely broken out, patient's lower body trapped under dash with left arm twisted into wreckage of door

Patient trapped under dash with >45 minutes required for extrication

ED

0515: Arrive as Trauma Alert

0520: P 86, R 20, BP 120/79, GCS 15

0645: P 115, R 20, BP 104/80, GCS 15

ED thought process: “Lucky kid”

Injuries:

- Complex pelvic fracture through acetabulum on left with left midshaft femur fracture
- Open left elbow fracture
- Grade 1 perirenal hematoma
- Right pulmonary contusion versus aspiration

ED

0735: P 130, R 20, BP 121/62

0746: Intubated

0800: P 138, BP 150/89

Given ~4500cc crystalloid

0830: P 131, BP 111/69 - Transport to Harborview

What has changed? Why?

Why hasn't his BP dropped?

Flight

In ambulance, BP drops to 60/30, P 140 – directed to pick up blood from ED – *is this isolated BP drop significant?*

At Missoula airport: P 125, BP 114/75

From 0943–1158, pulse ranged from 143–160 with most readings in the 150s

Patient never hypotensive

Packed cells not administered, another liter crystalloid administered

Multiple doses Fentanyl and Midazolam given

*Thinking pain/anxiety, should have been thinking
worsening bleeding → shock*

Harborview

pH 7.28, PCO₂ 35, **BE -8**

Receiving physician felt patient under-resuscitated

CVP 4-5 in ED

Given 9L crystalloid → florid pulmonary edema and ARDS

Harborview – ISS 41

- TBI diffuse axonal injury, grade 3 - ?????
- Acute Respiratory Distress Syndrome
- Ventilator Assisted Pneumonia
- Renal laceration – grade 3
- Open left humerus and olecranon fracture
- Transverse acetabular fracture
- Left femoral shaft fracture
- Left calcaneus and patella fracture
- Pneumomediastinum
- Significant episodes of sympathetic storming (fever, tachycardia, hypertension)

Disposition

- In Harborview for 40 days
- Transfer back to SNF in Missoula – was alert and responding appropriately to questions by blinking his eyes
- Then aspirated → 3 weeks at SPH with aspiration pneumonia, respiratory failure and continued storming
- Obtunded – occasionally opens eyes but no tracking or following commands
- Significant marked diffuse cerebral atrophy – “persistent vegetative state”
- Transfer to acute care rehab facility in Idaho

Our Review

- 43 minutes transpired between intubation in our ED to leaving for Harborview - should have done ABGs - If Base Deficit had been known prior to transport, the mind-set of the crew would probably have been different
- Need to reinforce the role of ABGs not only in assessing ventilatory status, but in assessing overall resuscitation
- Need to have a greater respect for the isolated low BP reading
- Need to have a greater respect for the clinical significance of persistent tachycardia, especially in the young, healthy trauma patient

PI Process

- Kudos to Flight RN – called me, “ You need to look at this because we screwed up.”
- Kudos to MICU staff – requested discussion about tachycardia in trauma
- I made presentation, took it to their staff meeting (held twice)
- Then adapted presentation, took it to ICU staff meetings at their request (held twice)
- Gave that presentation at Life Flight meeting (once) and ED staff meetings (twice)
- Cases reviewed at MDTC, ED Committee, RTAC and STCC
- Talk given at western region AACN conference
- That makes this the 10th venue in which I’ve discussed this topic

PI Process

- Spoke with numerous RNs and MDs – they all said the same thing...we always do ABGs post-intubation.....maybe not
- Policy generated: all newly intubated patients will have ABGs drawn 15 minutes post-intubation (medical as well as trauma)
- Posted in ED/ICU
- Discussed at ED Committee and staff meetings

PI Process

- Life Flight II (fixed wing) now has i-STAT (this was in the works prior to this case, but accepted much more readily because of it)
- Added lactate level to trauma panel
- All these events tracked and documented and a part of this patient's Trauma PI file
 - Copy of presentation
 - Meeting minutes
 - Attendance roster
 - Copy of postings

When your trauma patient has new or persistent tachycardia, think of this first.....

- Volume loss/bleeding

Think of these later.....

- Pain
- Anxiety/anger/fear
- Alcohol withdrawal
- Infection→sepsis
- Atelectasis/pneumonia/ARDS/pulmonary contusion/whatever lung funk causing hypoxia
- MI/cardiac injury/pericardial tamponade
- DVT→PE
- Compartment syndrome
- Ileus/abdominal compartment syndrome

Trauma is an Evolving Process

The ED did an assessment...they told you a story...now, four hours (or days) later, things have changed.....why?

- Maybe they missed something
- Maybe there was a communication breakdown
- Maybe the clinical situation has changed
 - Secondary brain injury
 - Expansion of hemothorax
 - Abdominal bleeding which hadn't declared itself initially
 - Cumulative, ongoing bleeding from multiple foci

Trauma is an Evolving Process

Remember: your patient's clinical condition is constantly changing

When you do your initial assessment, the picture you get in your mind is of that patient in that moment

The only guarantee you have is that the situation will change with time...hopefully for the better, but sometimes for the worse

Hope for the best, plan for the worst

Occam's Razor

In its simplest form, Occam's Razor states that one should not make more assumptions than needed. When multiple explanations are available for a phenomenon, the simplest version is preferred.

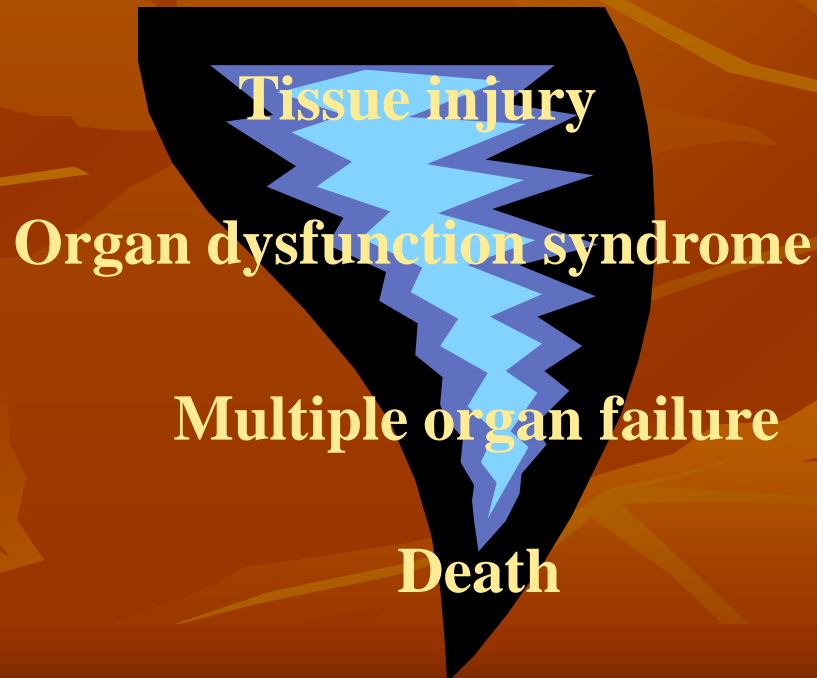
For example, a charred tree on the ground could be caused by a landing alien ship or a lightning strike. According to Occam's Razor, the lightning strike is the preferred explanation as it requires the fewest assumptions.

When you hear hoofbeats, think horses, not zebras

In trauma, when patients are unstable, don't out-smart yourself -
think bleeding, not autoimmune disorder

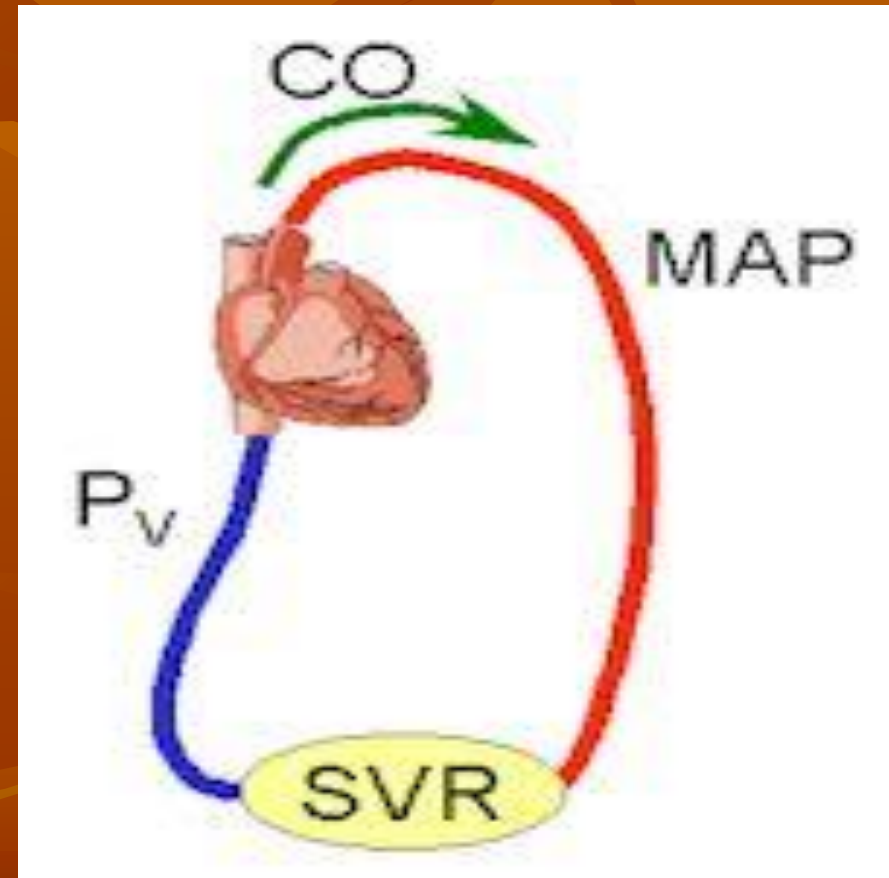
Shock

- Definition – Decreased utilization of oxygen by the tissues
- If prolonged → downward spiral



Physiology of Shock

- Respect persistent tachycardia as an early sign of hypovolemia, especially in the young, otherwise healthy patient
- Mean arterial pressure (MAP) reflects organ perfusion
- Influences to MAP:
 - Total blood volume
 - Cardiac function
 - Size of vascular bed
 - Sympathetic tone



Common Shock Pathways

■ Mechanisms

- Oxygen deficiency
- Cellular hypoxia
- Ischemia
- Anoxia



■ Compensation

- Increased circulating catecholamines
 - Increased HR, contractility
 - Vasoconstriction of both arterial and venous beds
 - Increase oxygen delivery
 - Increased cellular extraction of oxygen

3 Phases of Shock



Compensatory

Progressive

Irreversible

Leads to Acidosis

- Inadequate oxygen delivery, cellular extraction, and consumption result in cellular conversion to anaerobic metabolism for energy substrate production (ATP production)
- Increased production and release of lactate with resultant rising blood levels when tissue hypoxia occurs



Systemic Effects of Acidosis

- Respiratory: dyspnea, tachypnea, Kussmaul respirations, increased minute ventilation, decreased diaphragm contractility
- Cardiac: decreased catecholamine responsiveness, decreased fibrillation threshold, decreased contractility at pH <7.1
- Neurologic: increased cerebral blood flow, decreased cerebral metabolism, altered mental status → potential airway problems, increase sympathetic catecholamine discharge
- Other: decreased renal and hepatic perfusion, increased metabolic rate, increased protein catabolism

Definition of Systemic Inflammatory Response Syndrome (SIRS)

- Sustained, intravascular inflammation
- Uncontrolled host response to multiple stimuli
 - Any severe insult, not necessarily infection
- Triggers series of cascades
 - Creates an imbalance of cellular oxygen supply and demand
- Hallmark oxygen extraction deficit

SIRS

- Complex Inflammatory Pathways
 - Triggered by
 - Injury
 - Hypoxia
 - Hypoperfusion
 - Overwhelming sepsis
- Shock causes SIRS
- SIRS causes shock



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Who Develops MODS (Multiple Organ Dysfunction Syndrome)?

Research shows:

- Injury Severity Score (ISS) of ≥ 25 and received ≥ 6 units of blood
 - 46% risk for MODS
 - 30% mortality from MODS
- Dependent upon how many organs have failed and the severity of failure
 - MODS score – 2 or more
 - Some degree of coagulopathy
 - Infectious process with no identifiable focus
- Simply – those with significant organ dysfunction present 24 hours after injury

Resuscitation Endpoints

- Inadequate tissue oxygenation → anaerobic metabolism and tissue acidosis
- The depth and duration of shock → cumulative oxygen debt
- Resuscitation is complete when the oxygen debt has been repaid, tissue acidosis eliminated and normal aerobic metabolism restored in all tissue beds
- Some studies show the ability of a patient to attain supranormal O₂ delivery parameters correlates with an improved chance of survival – other studies have shown this not to be true

Resuscitation Endpoints

- HR, BP, UO no longer utilized in isolation to determine tissue oxygenation
- After normalizing these parameters, up to 85% of severely injured patients still have inadequate tissue oxygenation (occult hypoperfusion) based on metabolic acidosis or evidence of gastric mucosal ischemia
- Better measurements
 - Plasma lactate levels
 - ABGs: specifically base deficit
 - Serum bicarbonate levels may be substituted for base deficit levels

ABGs

- pH: information on acid-base balance by indicating concentration of hydrogen ions
 - <7.35 = acidosis
 - >7.45 = alkalosis
- Base excess: information on how much alkali there is in the blood (similar information as gained from HCO_3 level)
 - Base excess = alkalosis
 - Base deficit (also expressed as negative base excess) = acidosis

The under-resuscitated shock patient will have a low pH and a base deficit

Resuscitation Endpoints

- The time to normalization of base deficit, lactate and pHi (intramucosal pH as monitored by gastric tonometry) is predictive of survival
- Persistently high base deficit or low pHi (or progressive worsening of these parameters) may be an early indicator of complications (ongoing hemorrhage or abdominal compartment syndrome)
- Predictive value of base deficit may be limited by:
 - ETOH intoxication (good thing we don't have to worry about that here!)
 - Hyperchloremic metabolic acidosis
 - Administration of sodium bicarbonate

Resuscitation Endpoints

- Arterial pH not as useful as base deficit as it will be “defended” by the body’s compensatory mechanisms
- Any base deficit >5 : “Severe”
- Two-thirds of patients with an increasing base deficit had ongoing blood loss in one study
- Different study found these predictors of development of MODS:
 - Elevated base deficit
 - Elevated lactate
 - Transfusion requirements
 - Extremes of age
 - High ISS

ISS

ISS is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an Abbreviated Injury Scale (AIS) score allocated to one of six body regions (head and neck, face, chest, abdomen, extremity and external). Only the highest AIS score in each body region is used. The 3 most severely injured body regions have their score squared and added together to produce the ISS.

1-9: Single system, not severe

10-15: Moderately injured

16-25: Usually multi-system, significantly injured

>25: Critically injured

Resuscitation Endpoints

- Elevated base deficit not only predictive of mortality, but also of complications such as the need for blood transfusions and development of organ failure, particularly ARDS
- In one study, BD 6 or higher correlates strongly with increased need for blood transfusions, development of ARDS, renal failure, coagulopathy, MODS and increased LOS
- Optimal algorithms for fluid resuscitation, blood product replacement and the use of inotropes &/or vasopressors have not been determined

Intervention Goals

- Control of hemorrhage

Trend: increased usage of tourniquets and recently developed hemostatic agents used by military

- Rapid correct of hypoperfusion

Trend: more judicious use of crystalloids and earlier administration of packed cells with many centers going to 1:1 FFP to pRBC transfusion ratio (FFP and platelets to minimize risk of coagulopathy after massive transfusion)

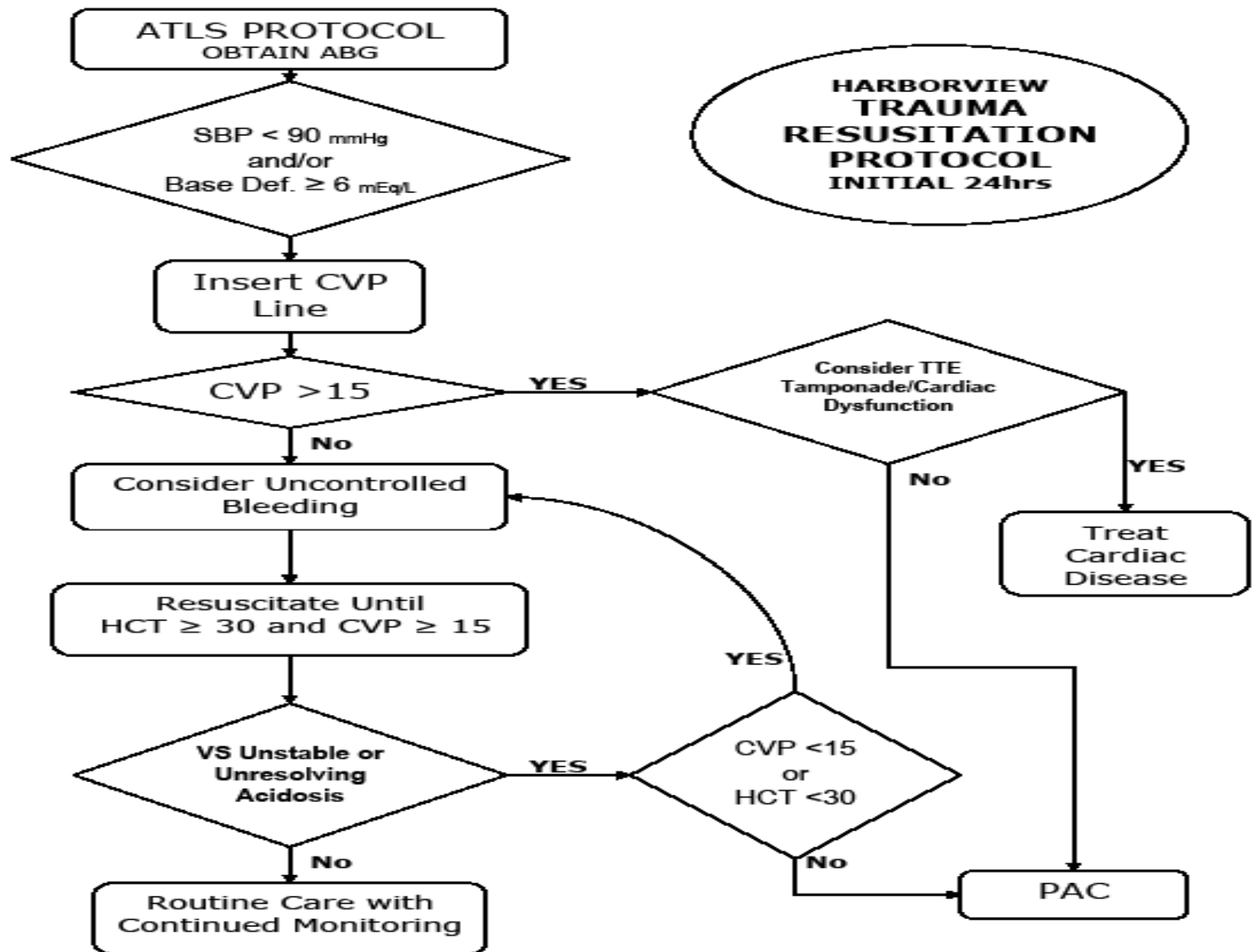
- Halt oxygen debt accumulation and repay oxygen debt

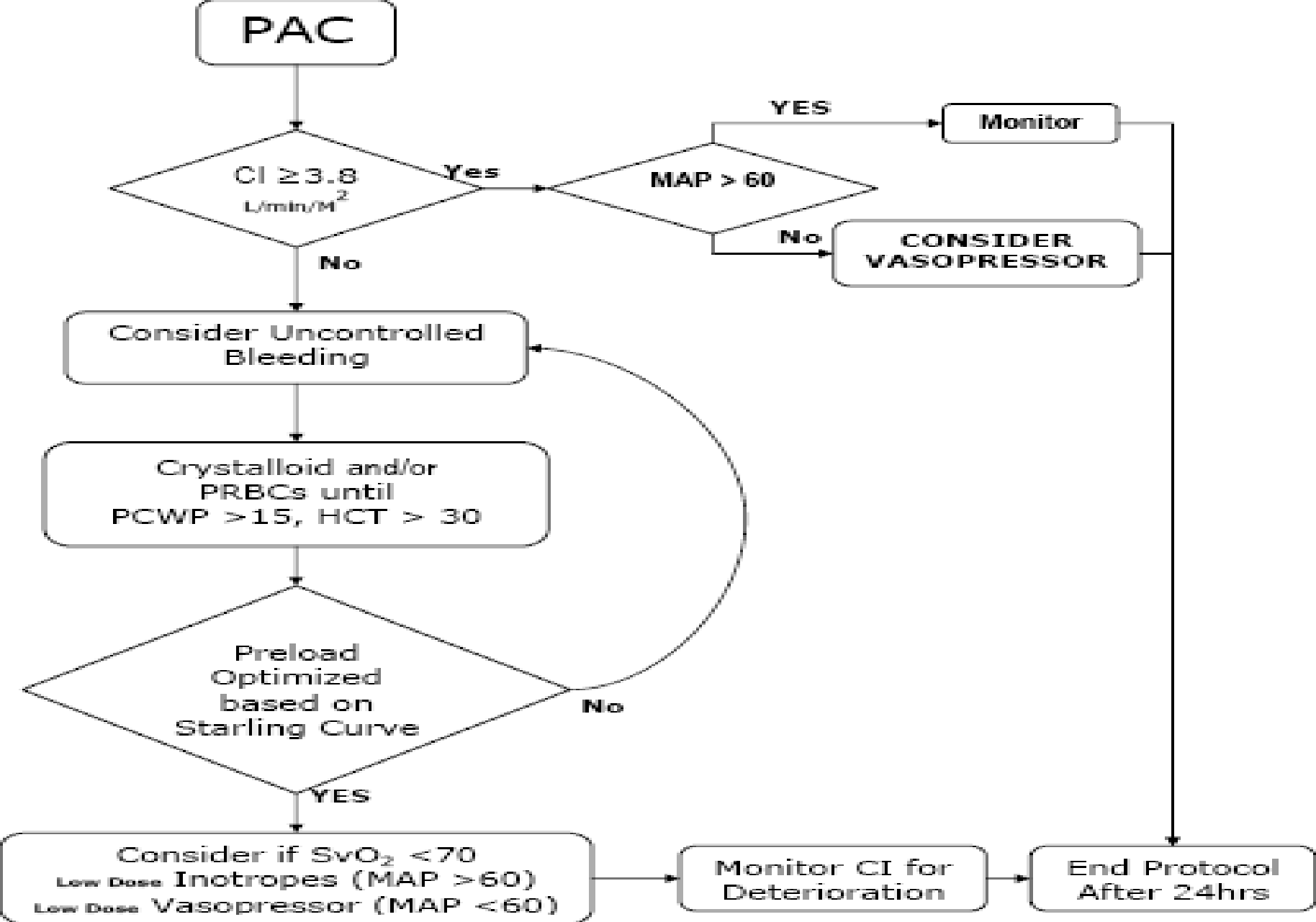
Intervention Goals

- Appropriate antibiotic administration

- Careful monitoring of resuscitation endpoints

Trend: increased monitoring of ABGs and lactate levels, bedside monitoring (i-STAT), monitoring of central venous pressures...determine further resuscitative needs based upon this data, not just vital signs and urine output





Shock Summary

Resuscitative efforts must focus on stopping development of cellular dysfunction resulting in the downward spiral to MODS and death.



Case #2

Event: 21 year old female passenger in rear seat of vehicle restrained only by lap belt – vehicle was T-boned and torn in half

Patient very small build

This case occurred 9 months after the previous one





First Facility

0814: Arrive

Found to have ruptured diaphragm, multiple areas of ruptured bowel, possible left iliac artery dissection, sacral fracture and L4 and L5 fractures

Became hypotensive and was taken to the OR for exploratory laparotomy

Abdomen left open with 2 Jackson-Pratt drains in place

Intubated - Left chest tube in place – Central line in place

Sheet to pelvis

Facility #1

0857: pH 7.15, PCO₂ 48, PO₂ 26, HCO₃ 18, **BE -12.0**

1032: Life Flight arrives, patient in surgery

1057: pH 7.17, PCO₂ 42, PO₂ 349, HCO₃ 15, **BE -12.6**

1114: H & H 11.3/33.8

1130: P 130s, BP 70s

Two units FFP infused

Plan to take four units PRBCs in flight

1150: Leave for ambulance – 400cc suctioned from JP drain

Vent: Assist/Controlled – Rate 10, fiO₂ 100, TV 500ml, PEEP 0

Transport

Original plan was to transport patient directly to Harborview – due to ongoing instability, plan changed to transfer to St. Pat's first for ongoing resuscitation and to get more blood products for the flight to Seattle

Ground to Missoula because of weather

1202: P 151, BP 64/38

1236: P 134, BP 110/56

Three units packed cells infused during transport to SPH

300cc additional JP drain evacuated

1327: Arrive SPH

SPH ED

pH 7.32, PCO₂ 37, PO₂ 339, HCO₃ 19, **BE -6.3**

P 120s, BP 109/83, temp 33.6R – 92.5(F) – Vitals improved...is she?

H & H 14.7/43.2

Platelets 70, PT 17.8, INR 1.8, PTT 39.1

Arterial line placed

Prior to transport to Harborview had received:

- >5 liters crystalloid
- 6 units packed cells
- 2 units FFP

Will receive additional products during flight to Seattle

1415: Depart for airport

Flight to Seattle

1430: P 127, BP 190/A-line

Suction of JPs and NG

Infusing packed cells, FFP and platelets

1600: pH 7.28, PCO₂ 51.8, PO₂ 389, HCO₃ 24.5, **BE -2**

Vent settings changed to Assist/Controlled, Rate 18, fiO₂ 100, TV 450ml

Heating FFP with Ranger

Saline infusing

1705: Arrive Harborview

Base Deficit went from 12.0 to 12.6 to 6.3 to 2

Injuries - ISS 50

- Probable traumatic brain injury
- Ruptured bowel
- Left iliac artery dissection
- Sacral fracture
- L4 and L5 fractures
- Left acetabular fracture
- Facial lacerations
- Ruptured diaphragm
- Prolonged shock

Outcome

- Arrived with temp 34.8(C) – 94.6(F) with worsening coagulopathy
- Multiple abdominal surgeries
- Spinal and pelvic surgery – “likely has a complete cauda equina injury given the operative findings of avulsed roots”
- Some feeling in legs, wiggling toes, doing PT
- Alert and oriented
- Eating solid foods
- Eventual discharge home

Outcome

To be critically injured outside a small town in rural Montana in cold weather and have an ISS of 50 and have this outcome.....amazing!

Interesting Footnote

Why did I make a point of saying that the second case occurred 9 months after the first one?

Interesting Footnote

Because the same flight crew was involved in both cases

They are convinced that the care rendered in the first facility and the resuscitation provided in the transports to Missoula and Seattle saved this patient's life...that what they learned from the first case helped the second

Performance improvement isn't just about checking data points on paper – it's about improving patient care – and it works

Summary

- Trauma is an evolving process – injuries can get better with time, they can also worsen
- Tachycardia is an early sign of shock
- When trauma patients are tachycardic, think blood loss first
- Must monitor and make resuscitative decisions based upon base deficit, lactate levels and CVP readings, not just P, BP and UO
- After normalizing P, BP and UO, up to 85% of severely injured patients still have inadequate tissue oxygenation
- Resuscitation is complete when the oxygen debt has been repaid, tissue acidosis eliminated and normal aerobic metabolism restored in all tissue beds
- PI can → improvements in patient care